REPORT
Prepared For
GOVERNMENT OF NORTHWEST TERRITORIES
DEPARTMENT OF RENEWABLE RESOURCES

Sampling and Analysis of Snow Cores In the Yellowknife Area

APRIL 1986

90-02657/

Stanley Associates Engineering Ltd.
Suite 305, Medical Arts Building
Box 1410
Yellowknife, Northwest Territories X1A 2P1
Phone (403) 920-4843

May 1, 1986
File: 53-005-01-01

Mr. L. C. James, Pollutions Control Engineer
Pollution Control Division
Department of Renewable Resources
Government of the Northwest Territories
Yellowknife, Northwest Territories
X1A 2C9

Dear Sir:

Reference: Sampling and Analysis of Snow Cores on the Yellowknife Area

We are pleased to present our Report on the snow core sampling and analysis program carried out in March 1986.

Our assessment of the arsenic levels in the snow cores shows reductions in arsenic levels in snow in 1986 compared to the levels reported in the Environment Canada Report for 1975:

Arsenic Concentrations

1986 Results	0.028 mg/L
1975 Results	0.17 mg/L

This represents a reduction of 84%.

Arsenic Deposition Rates

1986 Results	0.40 kg As/km^2/month
1975 Results	2.23 kg As/km^2/month

This represents a reduction of 82%.

In terms of comparison with the Canadian Drinking Water Standard (0.05 mg/L):

1986 Results	33% of all samples greater than the standard.
1975 Results	83% of all samples greater than the standard.

Canada Export Award / Prix d'excellence à l'exportation canadienne

Stanley

We trust this report meets your requirements and we are available at your convenience to dicsuss it with you.

Yours very truly,

STANLEY ASSOCIATES ENGINEERING LTD.

D. R. Burgess, P.Eng.
Manager, Yellowknife Office

Dr. A. Lamb, P.Eng.
Senior Consultant, Environmental

AL/cr

TABLE OF CONTENTS

		Page
LIST OF FIGURES		
LIST OF TABLES		
1.0	**INTRODUCTION**	1.1
1.1	BACKGROUND	1.1
	(a) Task Force Report on Arsenic	1.2
	(b) Previous Studies	1.3
1.2	STUDY SCOPE AND OBJECTIVES	1.4
2.0	**SNOW SAMPLING AND ANALYTICAL TECHNIQUES**	2.1
2.1	FIELD SAMPLING	2.1
2.2	FIELD SAMPLE LOCATIONS	2.2
2.3	CHEMICAL ANALYSIS	2.3
3.0	**DATA ANALYSIS**	3.1
3.1	APPROACH	3.1
3.2	DATA COMPILATION	3.1
3.3	EVALUATION OF ARSENIC DATA	3.2
	(a) Arsenic Concentrations	3.2
	(b) Arsenic Deposition Rates	3.4
3.4	EVALUATION OF pH LEVELS	3.8
3.5	EVALUATION OF SULFATE LEVELS	3.9
3.6	EVALUATION OF SULFITE LEVELS	3.10
4.0	**CONCLUSIONS**	4.1
5.0	**BIBLIOGRAPHY**	5.1
APPENDIX A		

FIGURES AND TABLES (LOCATED AT THE END OF SECTION 3)

LIST OF FIGURES

FIGURE 1 SNOW SAMPLING SITE LOCATIONS

FIGURE 2 ARSENIC DEPOSITION RATES

FIGURE 3 ARSENIC DEPOSITION ISOPLETHS

LIST OF TABLES

TABLE 1 SNOW SAMPLE LOCATIONS

TABLE 2 SNOW CORE ANALYSES

TABLE 3 COMPARISON WITH EPS RESULTS (1975)

TABLE 4 CALCULATED DEPOSITION OF ARSENIC (tons As/mi^2/month)

TABLE 5 CALCULATED DEPOSITION OF ARSENIC (kg As/km^2/month)

TABLE 6 COMPARISON OF DEPOSITION OF ARSENIC (1986 AND 1975)

TABLE 7 AVERAGE SULFATE LEVELS IN SNOW CORES

TABLE 8 AVERAGE SULFITE LEVELS IN SNOW CORES

TABLE A SAMPLING AND ANALYSIS - REPEATABILITY OF RESULTS

SECTION 1
INTRODUCTION

1.0 INTRODUCTION

1.1 BACKGROUND

The City of Yellowknife is located on the north shore of Great Slave Lake in the Northwest Territories; there are two gold producing companies located in close proximity to the City:

i) Giant Yellowknife Gold Mines Limited (Giant), 5.6 km to the north of the City.

ii) Con Mine, 0.8 km to the south of the City.

Arsenic is widely distributed in nature and is found principally in gold and other ores. It occurs naturally in the gold ore that is in the Yellowknife area, mainly as arsenopyrites. In the gold recovery process, the ore that contains gold is crushed; the ore concentrate contains a mixture of gold and sulfide.

In the Giant operation, the concentrate is roasted at 480°C to remove arsenic, sulphur and antimony, resulting in a porous material which is treated with cyanide to remove the gold that is recovered by precipitation, followed by recovery in a furnace. Volatile products produced in the roasting process contain arsenic trioxide and sulphur dioxide, which may be emitted to atmosphere if not controlled.

(In contrast, the gold recovery operations at the Con Mine do not include a roasting process and, therefore, arsenic emissions are limited to fugitive emissions from the baghouse system and from slurry containing arsenic held in tailings ponds. There has been no ore roasting at the Con Mine since November 1970.)

a) Task Force Report on Arsenic

In June 1977 the Federal Minister of National Health and Welfare requested that the Canadian Public Health Association set up a Task Force to study the issue that there was a serious health hazard in the Yellowknife area due to arsenic poisoning. The Task Force[1] concluded its deliberations and produced a comprehensive report containing 46 recommendations, which included the following:

Recommendation 6 - That every effort be made to ensure that melting snow is not used as a potable water source in the Yellowknife area.

Recommendation 8 - That Giant Yellowknife Gold Mines Ltd. take immediate steps to reduce arsenic air emissions.

(It is noted that the Recommendations originally presented in the Task Force Report have been edited for this report).

The Final Report by the Task Force on Arsenic also included a review of the detailed investigations of arsenic levels in snow carried out by Environment Canada in 1975.[2] (This Snow Survey is discussed briefly in the next sub-section, and the data from this Snow Survey are used as a basis for comparison with data obtained during the subject study.)

As a result of the Environment Canada 1975 Snow Survey, a number of Recommendations were made, including the following:

Recommendation 2 - That further studies be carried out to measure the concentration of arsenic in spring run-off and determine the final fate of the arsenic.

Recommendation 3 - On completion of recommended studies, rates and release of arsenic should be decreased to levels which will adequately mitigate undesirable environmental effects.

(It is noted that the Recommendations originally presented in the Environment Canada Report have been edited for this report).

b) Previous Studies

Two studies carried out by Environment Canada are used for comparing and contrasting data produced in the subject study. They are as follows:

i) "Chemical Characteristics of Snow in the Yellowknife Area, N.W.T., 1975" (Environment Canada, 1977).[2]

ii) "Arsenic Concentrations in Suspended Unsettleable Particulate Matter in Yellowknife, N.W.T." (Environment Canada, 1979).[3]

The 1975 Environment Canada Study, involved snow cores and snow scoop samples taken during March and April 1975 as part of an overall Yellowknife Environmental Survey. There were two principal objectives of the snow survey:

i) To quantify the concentration of arsenic in melted snow water.

ii) To assess deposition rate of arsenic during the winter.

A number of conclusions were drawn from this intensive survey:

- Concentrations of arsenic in samples of snow collected in the vicinity of Yellowknife generally exceeded maximum permissible levels as given in the Canadian Drinking Water Standards and Objectives.

- The estimated mean deposition rate of arsenic in the Yellowknife area was 1.9 kg arsenic per km^2 per month.

- The mean concentration of arsenic in melted snow core samples was 0.17 mg/L.

- The pH of snow in the vicinity of Yellowknife and in more distant areas did not generally fall within the range specified by the Canadian Drinking Water Standards and Objectives.

The 1978 Environment Canada Study reported on results from hi-vol suspended particulate levels, snow and settleable particulate samples as part of an ongoing arsenic monitoring program. A number of conclusions were drawn from the survey for 1978:

- The mean concentrations of arsenic in snow core samples was 0.05 mg/L, significantly reduced from values obtained in 1975.

- Concentrations of arsenic in 50% of the total of 54 samples collected exceeded to Canadian Drinking Water Standards and Objectives, compared to 83% of the samples exceeding the Standards and Objectives based on the 1975 Survey.

1.2 STUDY SCOPE AND OBJECTIVES

The scope and objectives of the subject study are presented within the framework of the detailed survey carried out by Environment Canada in 1975 (presented briefly above). The overall objectives of the subject study were as follows:

- To undertake a snow core sampling and analysis program to provide comparative data with the 1975 Environment Canada Study. These data would be used to assess changes in deposition of arsenic in the Yellowknife area as a result of the introduction of emission abatement equipment at the Giant Yellowknife Mines Ltd. (Giant) gold roasting operation.

- To determine present concentrations of sulfates and pH values of snow core samples as an initial step in examining sulphur dioxide emissions in the area.

- To analyze a number of samples, randomly selected, for sulfite.

In carrying out the subject study, it was required that the sampling locations for snow cores would be patterned as close as possible after the 1975 Environment Canada Study.

The work program followed in this study was set out in the Stanley Associates Engineering Ltd. proposal, addressed to Mr. L. C. James, Pollution Control Division, Department of Renewable Resources, Government of the Northwest Territories, and dated January 9, 1986. The information obtained from the two Environment Canada Studies, discussed above, was supplemented by discussions with personnel involved in these studies.

SECTION 2
SNOW SAMPLING AND ANALYTICAL TECHNIQUES

2.0 SNOW SAMPLING AND ANALYTICAL TECHNIQUES

2.1 FIELD SAMPLING

Snow sampling techniques are very important in order to be able to draw meaningful conclusions from the data obtained. Specific snow sampling techniques were outlined in the Stanley Proposal dated January 9, 1986.

The following techniques were used:

1. A "corer" comprising a 4.0" internal diameter "ABS" pipe was used. A steel tape was fastened to the side of the coring tool in order to monitor snow depths.

   Once the tool was inserted into the snow, the snow was removed from one side of the corer and a shovel was used to contain the snow within the tube.

   The corer containing the snow was transferred to a wooden form and the snow core was extruded using a capped 3" diameter ABS pipe.

2. The bottom 5 cm of the snow core was removed and discarded to avoid any anomalies resulting from migration of arsenic from the ground surface into the bottom snow layer.

3. The remaining core was subdivided into three equal sections:

   - o top section
   - o middle section
   - o bottom section

   and all sub-cores were bagged, the bags evacuated and labelled.

4. The length of the divided cores was measured to provide approximate bulk densities of the snow.

5. There were four cores initially collected for each site to ensure that adequate snow melt water would be obtained to carry out the required analyses. The total number of cores at each specific site was later reduced to three or to two, to ensure a minimum of 250 ml of snow melt water per site for analysis.

6. The bagged snow samples were melted and bottled prior to shipment for analysis.

7. Sample sites were located in open areas to avoid inclusion of snow drift in the overall sample.

8. Sampling on Yellowknife Bay with the coring tool was not possible because of the compact snow. Therefore, blocks of snow were cut from each site. Approximate volumetric measurements of the blocks of snow were taken in order to obtain a bulk density of the snow.

2.2 FIELD SAMPLE LOCATIONS

Site locations for the snow cores and the snow blocks from Yellowknife Bay and the description of the sites are given in Table 1. The following points are noted:

1. All sampling took place on March 7 and 8, 1986. Weather conditions were representative of winter in early March in the Yellowknife area.

2. The site locations given in Table 1 and shown in Figure 1 approximate, as far as possible, the sites used in the 1975 Environment Canada Study.

3. Sites 1 - 4 located due west of the mine were not sampled because of lack of winter roads for access at the time of sampling.

4. A number of samples were destroyed in transit:

- o Sample 30 - Yellowknife Bay
- o Sample 31 - Yellowknife Bay
- o Sample 5 (top and bottom sections) - taken approximately 1 km west of the mine

In total, 42 snow samples were taken, comprising 29 snow core samples and 13 samples from Yellowknife Bay.

The total snow depth is given in Table 1; it is noted that the snow depth was approximately constant, ranging from 47 cm - 58 cm, apart from the 13 Yellowknife Bay samples (18 cm) and a relatively shallow snow core (40 cm) at Site 9 (Airport Weather Station). The lower snow depth at the Airport Weather Station may have been associated with airport activities and the proximity of the sampling location to the runway.

The lengths of each top, middle and bottom section of the cores were calculated based on the total snow depth, and taking into account the rejection of the bottom 5 cm of the snow core. The average core section lengths are given in Table 1. Inspection of these data shows that the average core length ranged from 14 cm - 17 cm (omitting Site 9 for the reasons discussed above).

2.3 CHEMICAL ANALYSIS

Each sample of melt water was homogenized and a 250 ml sample was taken for chemical analysis. The following parameters were measured:

- o arsenic
- o pH
- o sulfate

These data are presented in Table 2.

Five samples were selected at random and analyzed for sulfite.

The analytical technique NAQUADAT 33001 was used to determine total arsenic in the samples. The determinations of sulfite, sulfate and pH were in accordance with "Standard Methods for the Examination of Water and Wastewater" 16th ed. APHA, AWWA, WPCF.

In addition to the blind duplicate samples that were analyzed, a known standard was included with every batch of eight samples in order to check instrument operation.

A number of duplicate samples were run during the course of the laboratory analyses. These data (presented in Appendix A) indicate that the accuracy of the arsenic analysis is $\pm$ 0.005 mg/L up to the 0.100 mg/L level and 0.025 mg/L at the 1.0 mg/L level.

SECTION 3
DATA ANALYSIS

3.0 DATA ANALYSIS

3.1 APPROACH

The snow cores were divided into three equal lengths, and each sub-core was analyzed for arsenic, sulfate and pH. Average values for the total core were determined for both arsenic and sulfate and were used as a basis for data analysis and for comparison with the 1975 Environment Canada results.

The intent of dividing the snow cores into top, middle and bottom sections was to determine if it were feasible to assess any variation in arsenic deposition with time. Although snow precipitation data are known for the 1986 winter in the Yellowknife area, comparison of these data on a time basis with actual snow quantities obtained from the cores only gives an approximate time scale. Nevertheless, it should give some indication of time periods for any major differences in concentrations of arsenic in the snow melt water (and, by inference, arsenic deposition rates during the periods of time represented by the snow cores).

3.2 DATA COMPILATION

The locations of the sampling sites in the Yellowknife area are presented in Table 1. Concentrations of arsenic for each of the sub-cores for each of the site locations are presented in Table 2.

It is noted that core sampling was not possible at the Yellowknife Bay locations and that a number of samples were destroyed in transit from Yellowknife to Edmonton. These items are addressed specifically in Table 1 and in subsequent data tables.

The following general points are made regarding the data presented in Table 2:

- Site locations 1 - 4, located due west of the mine were not sampled because of lack of access by winter roads at the time of sampling.

- Samples taken from Locations 30 and 31 were destroyed in transit from Yellowknife to Edmonton.

- The top and bottom sample from Location 5 were destroyed in transit from Yellowknife to Edmonton.

- Locations 32 and 35 - 44 were on Yellowknife Bay; due to the compact nature of the snow, it was not possible to use the coring tool, and therefore, block samples of snow were taken. Consequently, only values for arsenic, sulfate and pH representing the total sample were obtained.

These single results are presented in the "Average" column (arsenic and sulfate) and in the "middle" column for pH in Table 2.

3.3 EVALUATION OF ARSENIC DATA

The major objective of the study was to compare the results of snow core samples taken during the present (1986) Study (representing the winter of 1985/86) and the 1975 Environment Canada Study (representing the Winter of 1974/75).

a) Arsenic Concentrations

The actual results obtained from the 1975 Environment Canada Study are presented in Table 3, in conjunction with the 1986 Study results. Sampling site locations are given in Figure 1.

The difference between the 1975 and the 1986 data are compared in terms of a ratio (%) and a decrease (%) of the 1986 data compared to 1975.

The following conclusions may be drawn from inspection of the data presented in Table 3:

- o Decreases in arsenic levels in snow core samples have occurred in the Yellowknife area in 1986 compared to 1975, ranging from 10% to 99%.

- o Arsenic levels presented may be compared with the Canadian Drinking Water Standard (0.05 mg/L).

  - 1986 results -13 samples greater than the standard (33% of all samples).

  - 1975 results - 54 samples greater than the standard (83% of all samples).

- o In terms of arsenic levels greater than 0.5 mg/L (10 times the Drinking Water Standard):

  - 1986 results - 1 sample (3% of all samples taken)

  - 1975 results - 9 samples (15% of all samples taken)

- o The arsenic results from the two studies may be expressed as a geometric mean value (to take account of the wide spread in data):

- 1986 results - 0.028 mg/L

- 1975 results - 0.17 mg/L

This reduction in mean arsenic levels in snow in the Yellowknife area in 1986 compared to 1975 represents a reduction of 84%.

b) Arsenic Deposition Rates

Arsenic Deposition Rates for the 1986 study are presented in Table 4 (Tons Arsenic/mi.^{2}/month) and in Table 5 (kg Arsenic/km^2/month).

The report of the 1975 Environment Canada data included isopleths in tons Arsenic/mi.^{2}/month; the report also showed the following conversion factor for the 1975 study:

0.032 ton As/mi.^{2}/month = 1 ug As/L (equivalent to 1 mg As/L)

Deposition rates for the 1975 Environment Canada Study are also presented in Tables 4 and 5 for the purpose of comparison.

In order to facilitate examination of the 1986 data, they have been grouped as follows:

Range 1: 0.02 - 0.19 kg arsenic/km^2/month
Range 2: 0.20 - 0.34 kg arsenic/km^2/month
Range 3: 0.35 - 0.89 kg arsenic/km^2/month
Range 4: 0.90 - 3.5 kg arsenic/km^2/month
Range 5: Greater than 3.5 kg arsenic/km^2/month

Calculated deposition rates for each site are given in Figure 2.

In the 1986 Study, the following site locations fall into the above ranges as follows:

Range 1: Site Locations 8, 11, 12, 26, 27, 28, 33, 34, 35, 36, 51, 60.
Range 2: Site Locations 9, 13, 14, 15, 16, 17, 18, 19, 20, 24, 25, 29, 32, 37.
Range 3: Site Locations 10, 20, 21, 38, 39, 40, 43.
Range 4: Site Locations 22, 42, 44.
Range 5: Site Locations 6, 7, 23, 41.

These ranges are noted on Figure 2; the Site Locations given in Figure 1 are coincident with the locations in Figure 3.

Average deposition rates for each site location in the 1986 study are presented in Figure 3 in terms of kilograms arsenic/km^2/month. Superimposed on Figure 3 are the arsenic isopleths for the 1975 Environment Canada Survey taken from Figure 7 of the Environment Canada report, with a conversion of the isopleths from tons As/$mi.^2$/month to kilograms As/km^2/month. (It is noted that the specific isopleth locations given in the original Figure 7 from the Environment Canada Report have not been changed.)

A number of comments may be made regarding the data presented in Figures 2 and 3 in regard to arsenic deposition rates in 1986 compared to those found in 1975:

- In general, average levels of arsenic deposition rates in 1986 were approximately 18% of those in 1975.

- The general trend of decreasing deposition rates with more distant locations from the Giant operations found in 1975 is also found in 1986.

- Isopleths have not been drawn based on the 1986 data in a manner similar to the 1975 data, considering the lack of data for locations to the southeast of the Giant operation.

Nevertheless, it is considered feasible to group the 1986 data and compare group average values with those obtained from the data collected in 1975. These data are presented in Table 6. The comparisons are summarized as follows:

Group I: On the periphery of the Study Area
1975 average level reduced by 90% to 0.12 kg As/km^2/month

Group II: City of Yellowknife
1975 average level reduced by 39% to 0.33 kg As/km^2/month

Group III: City of Yellowknife and peripheral area
1975 average level reduced by 77% to 0.26 kg As/km^2/month

Group IV: Vicinity of Giant operations
1975 average level reduced by 78% to 1.00 kg As/km^2/month

Group V: Close proximity to Giant operations
1975 average level reduced by 66% to 5.48 kg As/km^2/month

Group VI: At the Giant mine
1975 average level reduced by 93% to 6.16 kg As/km^2/month

Mean Deposition Rates

The deposition data presented in Table 5 may be summarized by comparing values of geometric mean deposition rates. It is necessary to consider snow deposition rate during the period of study on a time basis. Snow fall amounts as melted water equivalent taken from the summary data provided by Atmospheric Environment Service, Environment Canada for the 1985/86 winter are as follows:

October 16 - 30, 1985	30.6 mm
November, 1985	31.4 mm
December, 1985	11.6 mm
January, 1986	11.4 mm
February 1986	10.8 mm
March 1 - 5, 1986	5.4
Total	**101.2 mm**

The following points are noted:

- o The first effective snowfall of the 1985/1986 winter commenced on October 16, 1985.

- o The last snowfall prior to the sampling period (March 7 and 8, 1986) was March 4, 1986.

- o Traces of rain falling during the period are included in the total precipitation.

The average snowfall depth encountered over the study area was 52.7 cm (based on data given in Table 1) and this is equivalent to 84.3 mm, assuming the measured ratio of snow to melt water of 0.16 applies to all onshore areas.

The measured value of 84.3 mm from the present 1986 Study is less than the liquid precipitation of 101.2 mm based on snowfall data from the Yellowknife weather office. This difference may be possibly due to some movement of snow due to wind in the open areas selected for sampling sites. Since the objective of the Study was to assess actual deposition rates on the ground, the quantity of snow deposited is required rather than an estimate of deposition based on total snow fall.

The precipitation data for October 1985 to March 1986 may be used to generate an approximate time scale for the deposition of the three subcores (Top, Middle and Lower) and the bottom 5 cm of the total core that was discarded. The time scale is calculated approximately as follows:

Top Section:	Dec. 21, 1985 to Mar. 6, 1985	(75 days)
Middle Section:	Nov. 12, 1985 to Dec. 20, 1985	(39 days)
Lower Section:	Oct. 21, 1985 to Nov. 11, 1985	(22 days)
Base	Oct. 16, 1985 to Oct. 20, 1985	(5 days)

Thus the deposition data presented in Table 5 to take account of an approximate deposition period to give the following geometric mean deposition rates:

1986 - top section	0.29 kg As/km^2/month
- middle Section	0.40 kg As/km^2/month
- lower section	0.45 kg As/km^2/month
Average	0.40 kg As/km^2/month

In Summary:	1986 -	0.40 kg As/km^2/month
	1975 -	2.23 kg As/km^2/month

Thus there is a reduction of 82% in the mean deposition rate of arsenic in 1986 compared to 1975.

3.4 EVALUATION OF pH LEVELS

In regard to pH values of the snow core samples, these were generally below the recommended pH drinking water (6.5 - 8.5) (two of the 40 samples had measured pH values within this range). Data are presented in Table 2.

The range of pH values measured is expected, considering the nature of snow and the presence of carbon dioxide that would tend to make the snow melt water slightly acidic.

Discussion of sulphur dioxide, sulfate formation and its presence in the snow cover is presented below.

3.5 EVALUATION OF SULFATE LEVELS

Levels of sulfate were measured in all sub-core (top, middle and bottom sections); the analytical results are presented in Table 2.

Inspection of Table 2 shows that sulfate levels are generally low:

0.5 mg/L	7 Sites (20% of total sites)
0.5 to 0.9 mg/L	10 Sites (25% of total sites)
1.0 to 1.9 mg/L	14 Sites (35% of total sites)
2.0 to 2.9 mg/L	6 Sites (15% of total sites)
3.0 mg/L	2 Sites (5% of total sites)

The average sulfate values were grouped in order to compare average levels in the vicinity of Giant, in the vicinity of the City of Yellowknife and on the periphery of the study area. These values are presented in Table 7 and are summarized below:

Group A: In the Vicinity of Giant Operations
Average Sulfate = 1.1 mg/L

Group B City of Yellowknife
Average Sulfate = 2.2 mg/L

Group C On the periphery of the study area
Average Sulfate = 1.3 mg/L

Thus it appears that measured sulfate levels in snow core are no higher in the vicinity of Giant operations compared to the remainder of the Yellowknife area. It also appears that sulfate levels are slightly higher in the vicinity of the City compared to the remainder of the study area. Comparison with pH values shows there is no relationship between measured pH and sulfate level based on average values given in Table 2.

It is noted that these measured sulfate levels (30 kg sulphate/km^2/month) are approximately an order of magnitude less than those found in an industrial/urban area (typical valves may range from 70 kg sulphate/km^2/month to 350 kg sulphate/km^2/month). Therefore it is difficult to draw firm conclusions regarding differences in levels between different parts of the Yellowknife area.

3.6 EVALUATION OF SULFITE LEVELS

Samples selected at random were analyzed for sulfite. Inspection of these data given in Table 8 for seven sites shows that sulfite levels were below the detectable limit (0.5 mg/L) for all sites. It is not expected that sulfite would be present, considering the oxidation process of sulphur dioxide to sulfate in the atmosphere.

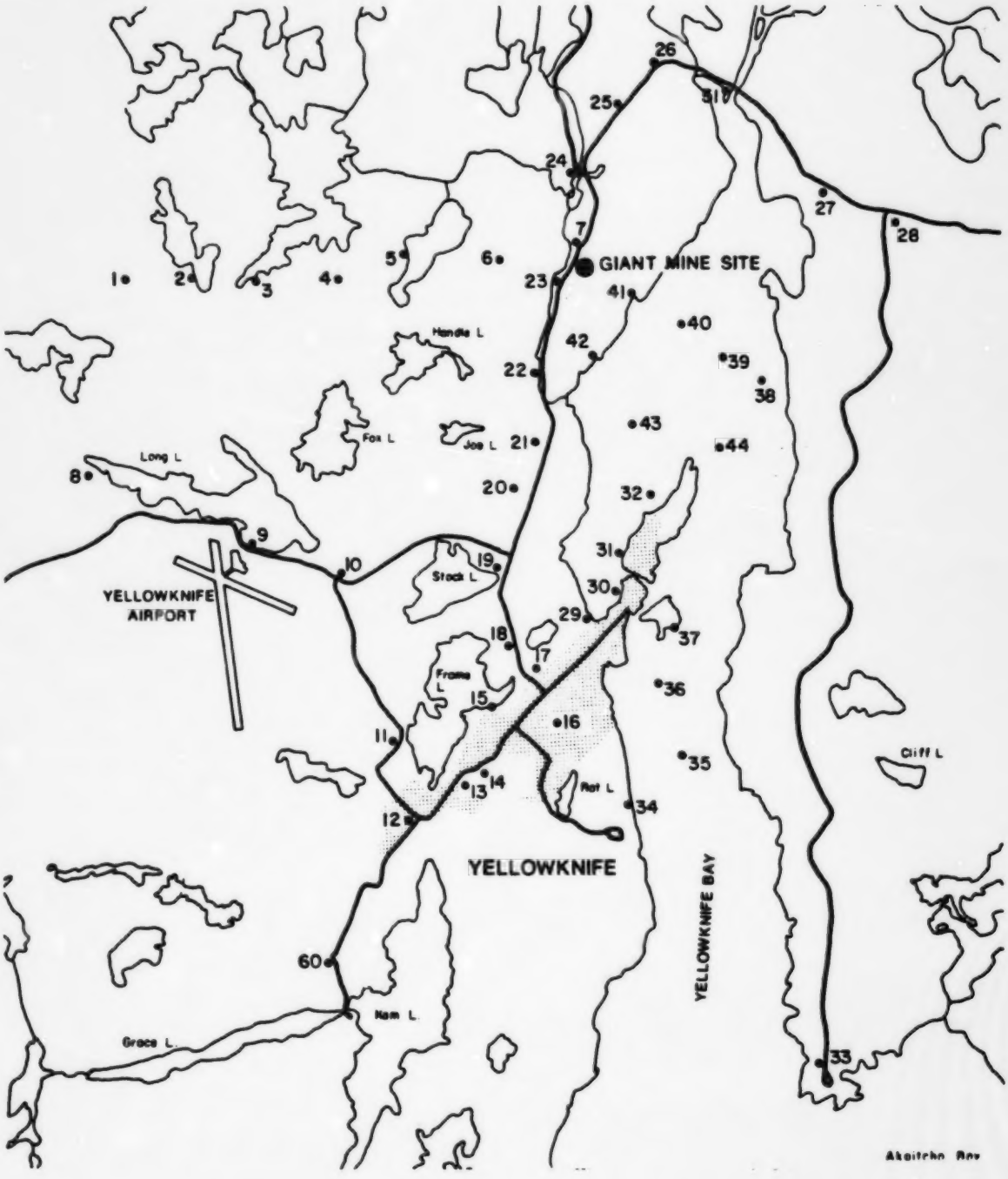

FIGURE 1
YELLOWKNIFE
SNOWCORE STUDY (1986)
SAMPLING LOCATIONS

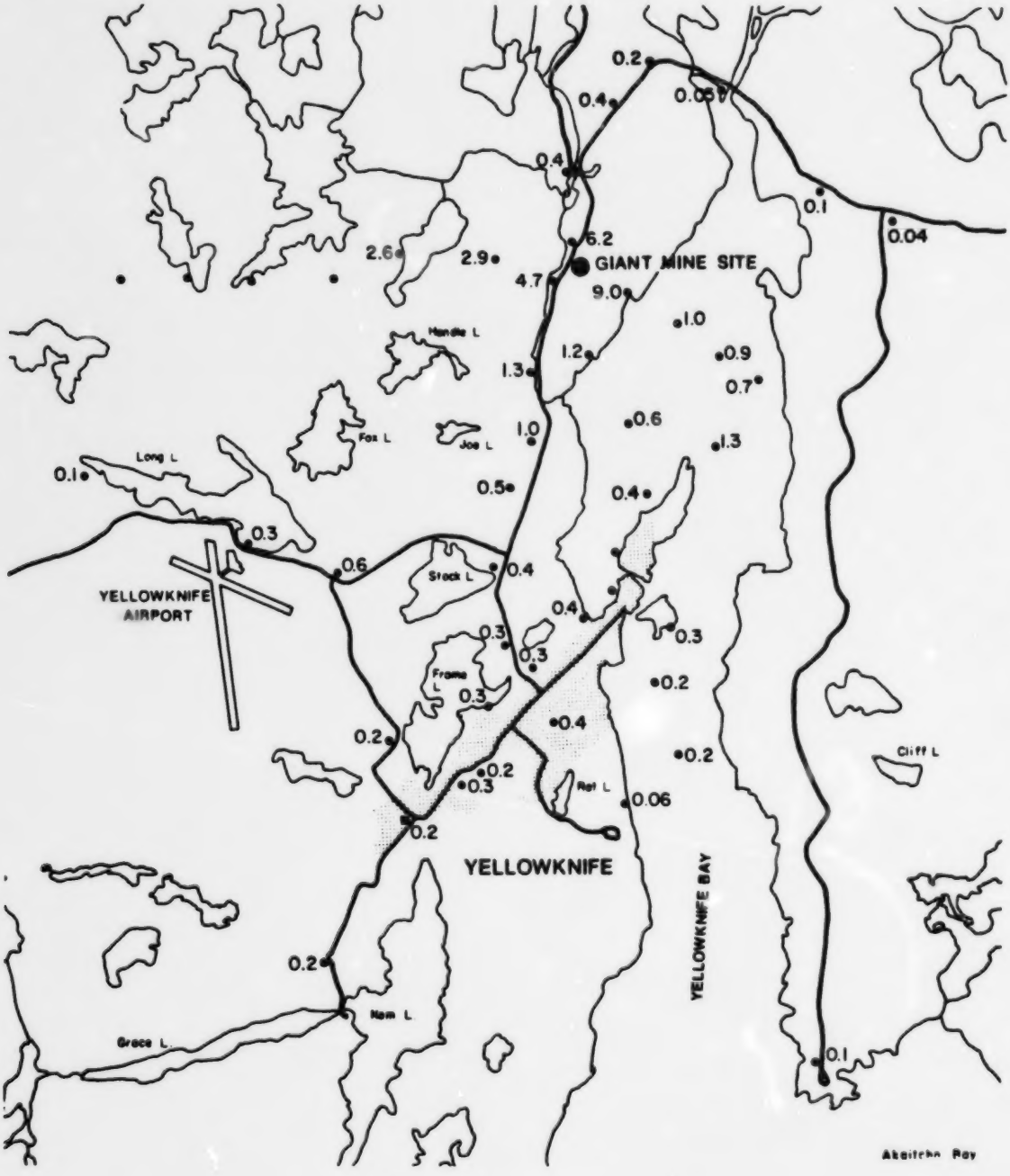

FIGURE 2
YELLOWKNIFE
SNOWCORE STUDY (1986)
ARSENIC DEPOSITION RATES
(kg/km^2/month)

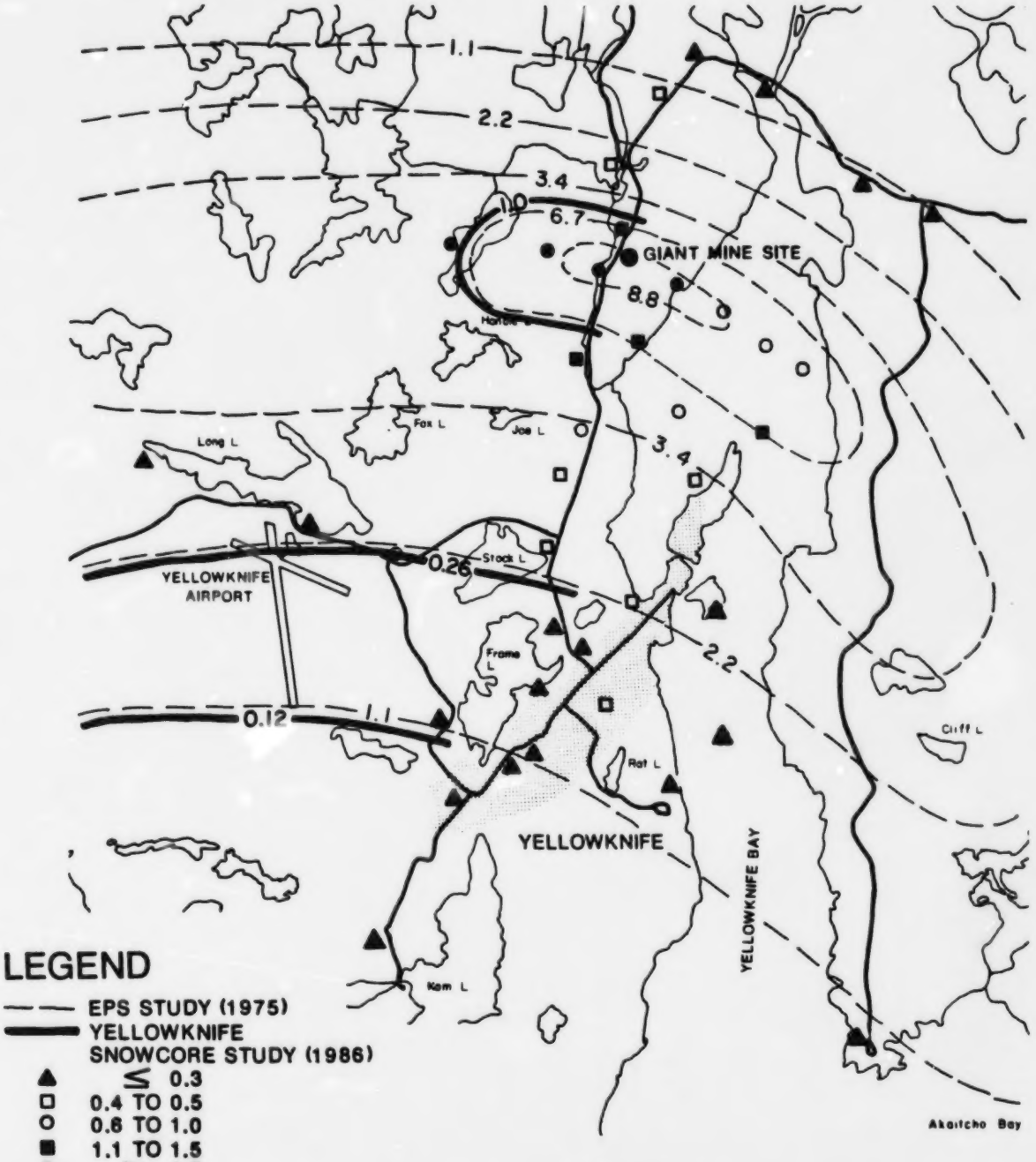

FIGURE 3
YELLOWKNIFE
SNOWCORE STUDY (1986)
ARSENIC DEPOSITION
ISOPLETHS
(kg/km^2/month)

SNOWCORE SAMPLES IN THE YELLOWKNIFE AREA

Table 1:SNOW SAMPLE LOCATIONS

Site location	DESCRIPTION	Total Snow depth (cm)	No. cores taken	T,M,B Core lengths (cm)
1	Sites 1 - 4 located due west of the mine.			
2	These sites were not sampled			
3	because of lack of access			
	by winter roads at the			
4	time of sampling.			
5	West of mine (approx 1 km) on shore unnamed lake	58	2	17
6	West of mine (approx 0.8km)	59	2	18
7	Giant Yellowknife mine	50	3	15
8	Yellowknife golf course	56	3	17
9	Airport weather station	40	3	11
10	Territorial Park	50	4	15
11	'Suicide' Corner	58	3	17
12	Water treatment pumphouse #4	56	3	17
13	Hill immediately behind CBC building	50	3	15
14	Ball diamond	52	3	15
15	Petitot Park	48	3	14
16	Vacant lot at 49 street/52 Avenue	52	3	15
17	Hotel incinerator at 49 street/47 avenue	56	3	17
18	Museum	52	2	15
19	NCPC	52	2	15
20	Garbage disposal	54	2	16
21	Fault lake	50	2	15
22	South of Giant mine (approx 1 km)	47	3	14
23	Giant mine main office	57	3	17
24	Wye road	47	3	14
25	North Gate	55	3	16
26	North Bend	52	3	15
27	North winter road	52	2	15
28	Detah turn off	57	3	17
29	Trailer park	58	2	17
30	Yellowknife bay	18*	block	
31	Yellowknife bay	18*	block	
32	Yellowknife bay	18*	block	
33	Detah village	50	2	15

NOTE: Dates sampled: March 7 and 8, 1986
Total core length - (total snow depth - 5 cm)
Top, Middle, Bottom lengths = (total core length(cm))/3
* core sampling on the lake not possible - block samples taken

SNOWCORE SAMPLES IN THE YELLOWKNIFE AREA

Table 1(cont): SNOW SAMPLE LOCATIONS

Site location	DESCRIPTION	Total Snow depth (cm)	No. cores taken	T,M,B Core lengths (cm)
34	Con mine wharf	49	4	14
35	Yellowknife bay	18*	block	
36	Yellowknife bay	18*	block	
37	Yellowknife bay	18*	block	
38	Yellowknife bay	18*	block	
39	Yellowknife bay	18*	block	
40	Yellowknife bay	18*	block	
41	Yellowknife bay	18*	block	
42	Yellowknife bay	18*	block	
43	Yellowknife bay	18*	block	
44	Yellowknife bay	18*	block	
51	Yellowknife river territorial park	56	3	17
60	Kam lake road	56	2	17

Average snow depth on shore = 52.7 cm

NOTE: Dates sampled: March 7 and 8, 1986
Total core length - (total snow depth - 5 cm)
Top, Middle, Bottom lengths = (total core length(cm))/3
* core sampling on the lake not possible - block samples taken

SNOWCORE SAMPLES IN THE YELLOWKNIFE AREA

Table 2: SNOW CORE ANALYSES

Site location	arsenic (ug/L)				pH			sulphate (ug/L)			
	top	middle	bottom	average	top	middle	bottom	top	middle	bottom	average
1	Sites 1 - 4 located due west of the mine.										
2	These sites were not sampled										
3	because of lack of access										
	by winter roads at the										
4	time of sampling.										
5	**	0.121	**		**	5.2	**	**	<0.5	**	
6	0.225	0.060	0.165	0.150	5.8	4.8	5.4	1.3	<0.5	1.0	0.8
7	0.815	0.165	0.175	0.385	7.3	5.9	5.5	2.7	<0.5	0.5	1.1
8	0.004	0.008	0.010	0.007	6.7	6.1	5.6	0.7	0.7	<0.5	0.5
9	0.024	0.022	0.022	0.023	6.8	6.4	6.1	1.4	2.2	1.1	1.6
10	0.020	0.027	0.062	0.036	6.9	7.0	6.5	1.4	4.4	2.2	2.7
11	0.006	0.011	0.011	0.009	6.7	6.0	6.8	3.6	4.9	1.1	3.2
12	0.009	0.013	0.010	0.011	6.6	6.3	6.3	3.1	4.7	1.6	3.1
13	0.029	0.027	0.007	0.021	6.1	6.3	5.8	3.0	1.3	<0.5	1.4
14	0.020	0.008	0.011	0.013	6.0	6.1	5.7	3.1	1.0	4.6	2.9
15	0.026	0.016	0.007	0.016	5.6	5.6	5.4	2.3	2.7	0.5	1.8
16	0.036	0.019	0.010	0.022	6.0	5.8	5.8	4.5	2.5	0.6	2.5
17	0.025	0.019	0.005	0.016	6.0	5.6	5.5	3.9	2.8	0.6	2.4
18	0.030	0.009	0.005	0.015	6.3	5.7	5.6	3.6	0.5	<0.5	1.4
19	0.033	0.013	0.018	0.021	6.5	6.1	5.8	1.7	1.1	<0.5	0.9
20	0.048	0.031	0.012	0.030	6.4	6.1	5.9	2.0	0.7	1.3	1.3
21	0.077	0.060	0.048	0.062	6.5	6.7	6.3	2.0	2.5	1.1	1.9
22	0.072	0.056	0.135	0.088	6.8	6.7	6.2	2.0	2.1	<0.5	1.4
23	0.430	0.110	0.200	0.247	7.4	8.3	6.9	3.9	2.5	1.1	2.5
24	0.035	0.017	0.019	0.024	7.1	6.5	6.6	1.8	<0.5	0.9	0.9
25	0.033	0.017	0.015	0.022	6.8	5.5	6.1	1.2	<0.5	0.9	0.7
26	0.023	0.010	0.005	0.013	6.9	5.9	5.6	1.8	<0.5	1.1	1.0
27	0.005	0.006	0.005	0.005	4.8	4.8	5.4	0.6	<0.5	<0.5	0.2
28	0.005	0.001	<0.001	0.002	5.8	5.9	5.7	0.8	<0.5	0.9	0.6
29	0.037	0.014	0.016	0.022	4.9	5.5	5.8	1.7	<0.5	1.4	1.0
30	destroyed in transit				destroyed in transit						
31	destroyed in transit				destroyed in transit						
32	*	*	*	0.041	*	5.8	*	*	*	*	0.9
33	0.019	<0.001	0.001	0.007	5.9	5.1	5.4	1.0	0.5	0.6	0.7

NOTE: Dates sampled: March 7 and 8, 1986

* core sampling on the lake not possible - block samples taken

** sample destroyed in transit

SNOWCORE SAMPLES IN THE YELLOWKNIFE AREA

Table 2(cont):SNOW CORE ANALYSES

Site location	arsenic (mg/L)				pH			sulphate (mg/L)			
	top	middle	bottom	average	top	middle	bottom	top	middle	bottom	average
34	0.010	<0.001	0.001	0.004	5.0	5.3	5.4	2.6	1.4	0.5	1.5
35	*	*	*	0.021	*	5.3	*	*	*	*	<0.5
36	*	*	*	0.020	*	5.6	*	*	*	*	<0.5
37	*	*	*	0.029	*	4.7	*	*	*	*	<0.5
38	*	*	*	0.074	*	4.7	*	*	*	*	<0.5
39	*	*	*	0.091	*	5.3	*	*	*	*	<0.5
40	*	*	*	0.095	*	5.6	*	*	*	*	<0.5
41	*	*	*	0.900	*	5.7	*	*	*	*	2.5
42	*	*	*	0.120	*	6.0	*	*	*	*	1.5
43	*	*	*	0.064	*	5.8	*	*	*	*	1.1
44	*	*	*	0.125	*	5.2	*	*	*	*	1.0
51	0.007	<0.001	0.002	0.003	5.8	5.8	5.6	<0.5	0.5	<0.5	<0.5
60	0.010	0.007	0.009	0.009	5.1	5.3	5.3	0.5	<0.5	<0.5	0.2

NOTE: Dates sampled: March 7 and 8, 1986
* core sampling on the lake not possible - block samples taken
** sample destroyed in transit

SNOWCORE SAMPLES IN THE YELLOWKNIFE AREA

Table 3:COMPARISON WITH EPS RESULTS (1975)

Site location	1986 STUDY RESULTS arsenic (mg/L) top	middle	bottom	average	EPS STUDY arsenic (mg/L) actual	Difference 1975 and 1986 data RATIO (%)	DECREASE (%)
1	Sites 1 - 4 located due west of the				0.400		
2	These sites were not sampled				0.400		
3	because of lack of access				0.700		
	by winter roads at the						
4	time of sampling.				0.600		
5	**	0.121	**		0.600		
6	0.225	0.060	0.165	0.150	0.800	19	81
7	0.815	0.165	0.175	0.385	8.000	5	95
8	0.004	0.008	0.010	0.007	0.060	12	88
9	0.024	0.022	0.022	0.023	0.100	23	77
10	0.020	0.027	0.062	0.036	0.060	61	39
11	0.006	0.011	0.011	0.009	0.070	13	87
12	0.009	0.013	0.010	0.011	0.060	18	82
13	0.029	0.027	0.007	0.021	0.050	42	58
14	0.020	0.008	0.011	0.013	0.020	65	35
15	0.026	0.016	0.007	0.016	0.090	18	82
16	0.036	0.019	0.010	0.022	0.050	43	57
17	0.025	0.019	0.005	0.016	0.050	33	67
18	0.030	0.009	0.005	0.015	0.200	7	93
19	0.033	0.013	0.018	0.021	0.100	21	79
20	0.048	0.031	0.012	0.030	0.200	15	85
21	0.077	0.060	0.048	0.062	0.200	31	69
22	0.072	0.056	0.135	0.088	0.200	44	56
23	0.430	0.110	0.200	0.247	0.200	123	-23
24	0.035	0.017	0.019	0.024	0.200	12	88
25	0.033	0.017	0.015	0.022	0.200	11	89
26	0.023	0.010	0.005	0.013	1.000	1	99
27	0.005	0.006	0.005	0.005	0.100	5	95
28	0.005	0.001	<0.001	0.002	0.300	1	99
29	0.037	0.014	0.016	0.022	0.070	32	68
30	destroyed in transit				0.200		
31	destroyed in transit				0.200		
32	*	*	*	0.041	0.100	41	59
33	0.019	<0.001	0.001	0.007	0.070	10	90

NOTE: Dates sampled: March 7 and 8, 1986

* core sampling on the lake not possible - block samples taken

** sample destroyed in transit

SNOWCORE SAMPLES IN THE YELLOWKNIFE AREA

Table 3(cont):COMPARISON WITH EPS RESULTS (1975)

Site location	arsenic (mg/L)				EPS STUDY arsenic (mg/L)	Difference 1975 and 1986 data	
	top	middle	bottom	average		RATIO (%)	DECREASE (%)
34	0.010	<0.001	0.001	0.004	0.080	5	95
35	*	*	*	0.021	0.300	7	93
36	*	*	*	0.020	0.100	20	80
37	*	*	*	0.029	0.100	29	71
38	*	*	*	0.074	0.500	15	85
39	*	*	*	0.091	0.400	23	77
40	*	*	*	0.095	2.500	4	96
41	*	*	*	0.900	1.000	90	10
42	*	*	*	0.120	0.400	30	70
43	*	*	*	0.064	0.400	16	84
44	*	*	*	0.125	0.700	18	82
51	0.007	<0.001	0.002	0.003	0.070	4	96
60	0.010	0.007	0.009	0.009	0.100	9	91

NOTE

SNOWCORE SAMPLES IN THE YELLOWKNIFE AREA

Table 4: CALCULATED DEPOSTION OF ARSENIC

Site location	Total snow depth (cm)	arsenic (mg/L)				deposition (tons As/mi2/month)				
		top	middle	bottom	average	top	middle	bottom	average	EPS STUDY
1		Sites 1 - 4 due west of mine								1.28E-02
2		These sites were not sampled								1.28E-02
3		because of lack of access								2.24E-02
		by winter roads at the								
4		time of sampling.								1.92E-02
5	58	**	0.121	**			7.51E-03			1.92E-02
6	59	0.225	0.060	0.165	0.150	7.40E-03	3.79E-03	1.85E-02	8.22E-03	2.56E-02
7	50	0.815	0.165	0.175	0.385	2.23E-02	8.70E-03	1.63E-02	1.76E-02	2.56E-01
8	56	0.004	0.008	0.010	0.007	1.24E-04	4.78E-04	1.06E-03	3.80E-04	1.92E-03
9	40	0.024	0.022	0.022	0.023	5.12E-04	9.02E-04	1.60E-03	8.05E-04	3.20E-03
10	50	0.020	0.027	0.062	0.036	5.48E-04	1.42E-03	5.79E-03	1.66E-03	1.92E-03
11	58	0.006	0.011	0.011	0.009	1.94E-04	6.83E-04	1.21E-03	5.02E-04	2.24E-03
12	56	0.009	0.013	0.010	0.011	2.80E-04	7.76E-04	1.06E-03	5.52E-04	1.92E-03
13	50	0.029	0.027	0.007	0.021	7.95E-04	1.42E-03	6.54E-04	9.59E-04	1.60E-03
14	52	0.020	0.008	0.011	0.013	5.72E-04	4.40E-04	1.07E-03	6.20E-04	6.40E-04
15	48	0.026	0.016	0.007	0.016	6.81E-04	8.06E-04	6.25E-04	7.13E-04	2.88E-03
16	52	0.036	0.019	0.010	0.022	1.03E-03	1.05E-03	9.76E-04	1.03E-03	1.60E-03
17	56	0.025	0.019	0.005	0.016	7.76E-04	1.13E-03	5.29E-04	8.45E-04	1.60E-03
18	52	0.030	0.009	0.005	0.015	8.59E-04	4.95E-04	4.88E-04	7.00E-04	6.40E-03
19	52	0.033	0.013	0.018	0.021	9.45E-04	7.16E-04	1.76E-03	1.02E-03	3.20E-03
20	54	0.048	0.031	0.012	0.030	1.43E-03	1.78E-03	1.22E-03	1.51E-03	6.40E-03
21	50	0.077	0.060	0.048	0.062	2.11E-03	3.16E-03	4.48E-03	2.82E-03	6.40E-03
22	47	0.072	0.056	0.135	0.088	1.84E-03	2.75E-03	1.18E-02	3.74E-03	6.40E-03
23	57	0.430	0.110	0.200	0.247	1.36E-02	6.70E-03	2.16E-02	1.30E-02	6.40E-03
24	47	0.035	0.017	0.019	0.024	8.95E-04	8.36E-04	1.66E-03	1.01E-03	6.40E-03
25	55	0.033	0.017	0.015	0.022	1.00E-03	9.95E-04	1.56E-03	1.10E-03	6.40E-03
26	52	0.023	0.010	0.005	0.013	6.58E-04	5.50E-04	4.88E-04	6.04E-04	3.20E-02
27	52	0.005	0.006	0.005	0.005	1.43E-04	3.30E-04	4.88E-04	2.54E-04	3.20E-03
28	57	0.005	0.001	<0.001	0.002	1.58E-04	6.09E-05	<4.1E-05	1.06E-04	9.60E-03
29	58	0.037	0.014	0.016	0.022	1.19E-03	8.69E-04	1.76E-03	1.20E-03	2.24E-03
30		destroyed in transit								6.40E-03
31		destroyed in transit								6.40E-03
32		*	*	*	0.041				1.17E-03	3.20E-03
33	50	0.019	<0.001	0.001	0.007	1.56E-03	<4.1E-05	9.34E-05	3.05E-04	2.24E-03

NOTE:
- 0.16 = mls water / ml snow
- 2.5 = number of months of snowfall (top)
- 1.3 = number of months of snowfall (middle)
- 0.7 = number of months of snowfall (lower)
- 0.25 = mls water / ml snow (Yellowknife bay)

SNOWCORE SAMPLES IN THE YELLOWKNIFE AREA

Table 4 (cont):CALCULATED DEPOSTION OF ARSENIC

Site location	Total snow depth (cm)	arsenic (mg/L)				deposition (tons As/mi2/month)				
		top	middle	bottom	average	top	middle	bottom	average	EPS STUDY
34	49	0.010	<0.001	0.001	0.004	8.04E-04	<4.1E-05	8.04E-05	1.64E-04	2.56E-03
35	18*	*	*	*	0.021	*	*	*	5.99E-04	9.60E-03
36	18*	*	*	*	0.020	*	*	*	5.71E-04	3.20E-03
37	18*	*	*	*	0.029	*	*	*	8.28E-04	3.20E-03
38	18*	*	*	*	0.074	*	*	*	2.11E-03	1.60E-02
39	18*	*	*	*	0.091	*	*	*	2.60E-03	1.28E-02
40	18*	*	*	*	0.095	*	*	*	2.71E-03	8.00E-02
41	18*	*	*	*	0.900	*	*	*	2.57E-02	3.20E-02
42	18*	*	*	*	0.120	*	*	*	3.43E-03	1.28E-02
43	18*	*	*	*	0.064	*	*	*	1.83E-03	1.28E-02
44	18*	*	*	*	0.125	*	*	*	3.57E-03	2.24E-02
51	56	0.007	<0.001	0.002	0.003	2.17E-04	<4.1E-05	2.12E-04	1.55E-04	2.24E-03
60	56	0.010	0.007	0.009	0.009	3.11E-04	4.18E-04	9.53E-04	4.49E-04	3.20E-03

SNOWCORE SAMPLES IN THE YELLOWKNIFE AREA

Table 5 CALCULATED DEPOSTION OF ARSENIC

Site location	Total snow depth (cm)	arsenic (mg/L) top	middle	bottom	average	deposition (kg As/km2/month) top	middle	bottom	average	EPS STUDY
1		Sites 1 - 4 due west of mine								4.48
2		These sites were not sampled								4.48
3		because of lack of access								7.85
		by winter roads at the								
4		time of sampling.								6.73
5	58	**	0.121	**			2.63			6.73
6	59	0.225	0.060	0.165	0.150	2.59	1.33	6.48	2.88	8.97
7	50	0.615	0.165	0.175	0.385	7.82	3.05	5.73	6.16	89.68
8	56	0.004	0.008	0.010	0.007	0.04	0.17	0.37	0.13	0.67
9	40	0.024	0.022	0.022	0.023	0.18	0.32	0.56	0.28	1.12
10	50	0.020	0.027	0.062	0.036	0.19	0.50	2.03	0.58	0.67
11	58	0.006	0.011	0.011	0.009	0.07	0.24	0.42	0.18	0.78
12	56	0.009	0.013	0.010	0.011	0.10	0.27	0.37	0.19	0.67
13	50	0.029	0.027	0.007	0.021	0.28	0.50	0.23	0.34	0.56
14	52	0.020	0.008	0.011	0.013	0.20	0.15	0.38	0.22	0.22
15	48	0.026	0.016	0.007	0.016	0.24	0.28	0.22	0.25	1.01
16	52	0.036	0.019	0.010	0.022	0.36	0.37	0.34	0.36	0.56
17	56	0.025	0.019	0.005	0.016	0.27	0.40	0.19	0.30	0.56
18	52	0.030	0.009	0.005	0.015	0.30	0.17	0.17	0.25	2.24
19	52	0.033	0.013	0.018	0.021	0.33	0.25	0.62	0.36	1.12
20	54	0.048	0.031	0.012	0.030	0.50	0.62	0.43	0.53	2.24
21	50	0.077	0.060	0.048	0.062	0.74	1.11	1.57	0.99	2.24
22	47	0.072	0.056	0.135	0.088	0.65	0.96	4.12	1.31	2.24
23	57	0.430	0.110	0.200	0.247	4.77	2.35	7.56	4.56	2.24
24	47	0.035	0.017	0.019	0.024	0.31	0.29	0.58	0.35	2.24
25	55	0.033	0.017	0.015	0.022	0.35	0.35	0.55	0.39	2.24
26	52	0.023	0.010	0.005	0.013	0.23	0.19	0.17	0.21	11.21
27	52	0.005	0.006	0.005	0.005	0.05	0.12	0.17	0.09	1.12
28	57	0.005	0.001	<0.001	0.002	0.06	0.02	<0.02	0.04	3.36
29	58	0.037	0.014	0.016	0.022	0.42	0.30	0.62	0.42	0.78
30		destroyed in transit								2.24
31		destroyed in transit								2.24
32		*	*	*	0.041				0.41	1.12
33	50	0.019	<0.001	0.001	0.007	0.55	<0.02	0.03	0.11	0.78

NOTE: 0.16 = mls water / ml snow
2.5 = number of months of snowfall (top)
1.3 = number of months of snowfall (middle)
0.7 = number of months of snowfall (lower)
0.25 = mls water / ml snow (Yellowknife bay)

SNOWCORE SAMPLES IN THE YELLOWKNIFE AREA

Table 5 (cont):CALCULATED DEPOSTION OF ARSENIC

Site location	Total snow depth (cm)	arsenic (ug/L)				deposition (kg As/km2/month)				
		top	middle	bottom	average	top	middle	bottom	average	EPS STUDY
34	49	0.010	<0.001	0.001	0.004	0.28	<0.01	0.03	0.06	0.90
35	18+	*	*	*	0.021	*	*	*	0.21	3.36
36	18+	*	*	*	0.020	*	*	*	0.20	1.12
37	18+	*	*	*	0.029	*	*	*	0.29	1.12
38	18+	*	*	*	0.074	*	*	*	0.74	5.60
39	18+	*	*	*	0.091	*	*	*	0.91	4.48
40	18+	*	*	*	0.095	*	*	*	0.95	28.02
41	18+	*	*	*	0.900	*	*	*	9.00	11.21
42	18+	*	*	*	0.120	*	*	*	1.20	4.48
43	18+	*	*	*	0.064	*	*	*	0.64	4.48
44	18+	*	*	*	0.125	*	*	*	1.25	7.85
51	56	0.007	<0.001	0.002	0.003	0.08	<0.02	0.07	0.05	0.78
60	56	0.010	0.007	0.009	0.009	0.11	0.15	0.33	0.16	1.12

TABLE 6

COMPARISON OF DEPOSITION OF ARSENIC
(1986 and 1975)

GROUP I: On the Periphery of the Study Area

Site Location	1986	1975
11	0.18	0.78
12	0.19	0.67
26	0.21	11.21*
27	0.09	1.12
28	0.04	3.36
33	0.11	0.78
51	0.05	0.78
Average	0.12	1.25

* Excluded from the average.

Reduction in Average level: 90%

GROUP II: City of Yellowknife

Site Location	1986	1975
14	0.22	0.22
16	0.36	0.56
17	0.30	0.56
29	0.42	0.78
Average	0.33	0.53

Reduction in Average Level: 39%

TABLE 6 CONT'D
COMPARISON OF DEPOSITION OF ARSENIC
(1986 and 1975)

GROUP III: CITY OF YELLOWKNIFE
AND PERIPHERAL AREA

Site Location	1986	1975
13	0.34	0.56
14	0.22	0.22
15	0.25	1.01
16	0.36	0.56
17	0.30	0.56
18	0.25	2.24
29	0.42	0.78
34	0.06	0.90
35	0.21	3.26
36	0.20	1.12
Average	0.26	1.13

Reduction in Average Level: 77%

TABLE 6 CONT'D
COMPARISON OF DEPOSITION OF ARSENIC
(1986 and 1975)

GROUP IV: VICINITY OF GIANT OPERATIONS

Site Location	1986	1975
22	1.31	2.24
23	Incl. in Group V	2.24
38	0.74	5.60
39	0.91	4.48
40	0.95	Incl. in Group V
42	1.20	4.48
43	0.64	4.48
44	1.25	7.85
Average	1.00	4.49

Reduction in Average Level: 78%

GROUP V: CLOSE PROXIMITY TO GIANT OPERATIONS

Site Location	1986	1975
6	2.88	8.97
23	4.56	Incl. in Group IV
40	Incl. in Group IV	28.02
41	9.00	11.21
Average	5.48	16.07

Reduction in Average Level: 66%

TABLE 6 CONT'D

COMPARISON OF DEPOSITION OF ARSENIC

(1986 and 1975)

GROUP VI: AT THE GIANT MINE

Site Location	1986	1975
7	6.16	89.7

Reduction in Average Level: 93%

NOTE: Site location #23 is anomalous in the 1975 data set.
Site Location #40 is anomalous in the 1986 data set.

TABLE 7

AVERAGE SULPHATE LEVELS IN SNOW CORES

GROUP A: VICINITY OF GIANT OPERATIONS

Site Location	Sulfate (mg/L)
6	0.8
22	1.4
23	2.5
38	< 0.5
39	< 0.5
40	< 0.5
41	2.5
42	1.5
43	1.1
44	1.0
Average	1.1

GROUP B: CITY OF YELLOWKNIFE

Site Location	Sulfate (mg/L)
14	2.9
16	2.5
17	2.4
29	1.0
Average	2.2

GROUP C: ON THE PERIPHERY OF THE STUDY AREA

Site Location	Sulfate (mg/L)
11	3.2
12	3.1
26	1.0
27	0.2
28	0.6
33	0.7
51	<0.5
Average	1.3

SNOWCORE SAMPLES IN THE YELLOWKNIFE AREA

Table 8: SULPHITE ANALYSIS

Site location	DESCRIPTION	sulphite (mg/L)			
		top	middle	bottom	average
7	Giant Yellowknife mine	<0.5	<0.5	<0.5	<0.5
22	South of Giant mine (approx 1 km)	<0.5	<0.5	<0.5	<0.5
28	Detah turn off	<0.5	<0.5	<0.5	<0.5
38	Yellowknife bay	<0.5	<0.5	<0.5	<0.5
41	Yellowknife bay	*	*	*	<0.5

NOTE: Dates sampled: March 7 and 8, 1986
* core sampling on the lake not possible - block samples taken

SECTION 4
CONCLUSIONS

4.0 CONCLUSIONS

The following conclusions may be drawn from the snow core sampling and analysis program carried out in the Yellowknife area on March 1986.

1. Decreases in arsenic levels in snow core samples have occurred in the Yellowknife area, ranging from 10% to 99% decrease over values obtained during 1975. The concentrations of arsenic in the snow may be expressed as geometric mean values:

   - 1986 Results 0.028 mg/L
     1975 Results 0.17 mg/L

   This reduction in mean arsenic levels in snow in the Yellowknife area in 1986 compared to 1975 represents a reduction of 84%.

2. In regard to arsenic deposition rate 1986 compared to that in 1975:

   - The arsenic deposition rate in 1986 was approximately 18% of that in 1975.

   - The general trend of decreasing deposition rates with more distant locations from the Giant Yellowknife Mines Ltd. operations found in 1975 is also found in 1986.

3. In terms of grouping the 1986 data and comparing average values with similar groupings of data collected in 1975:

   - The 1975 average level of deposition rates on the periphery of the Study Area is reduced by 90% to 0.12 kg As/km^2/month.

   - In the City of Yellowknife, the 1975 average levels had been reduced by 39% to 0.33 kg As/km^2/month.

- In the City of Yellowknife and peripheral areas, the 1975 average levels had been reduced by 77% to 0.26 kg As/km^2/month.

- In the vicinity of Giant Yellowknife Mines operations, the 1975 average level has been reduced by 78% to 1.0 kg As/km^2/month.

- In close proximity to the Giant Yellowknife Mine operations, the 1975 average arsenic levels have been reduced by 66% to 5.48 kg/As/km^2/month.

- At the Giant Yellowknife Mine Site, the 1975 average arsenic level has been reduced by 93% to 6.16 kg/As/km^2/month.

4. Decrease in deposition of arsenic in the Yellowknife area in 1986 compared to 1975 may be expressed in terms of the geometric mean deposition rate:

o	1986	0.40 kg As/km^2/month
o	1975	2.23 kg/As/km^2/month

This represents an 82% reduction in deposition rate.

5. The terms of assessment of arsenic concentrations in snow compared to the Canadian Drinking Water Standard (0.05 mg/L):

o	1986 Results	33% of all samples (13 samples) greater than the Standard.
o	1975 Results	83% of all samples (54 samples) greater than the Standard.

6. Levels of sulfate in the snow sampled in the Yellowknife area are generally low and range up to 3 mg/L. There is no significant difference between sulfate levels measured in the City of Yellowknife and in the vicinity of the Giant Yellowknife Mines operation. The measured sulfate levels are an order of magnitude less than those found in an industrial/urban area.

7. Sulfite levels in the snow were below the detectable limit (less than 0.5 mg/L).

SECTION 5
BIBLIOGRAPHY

5.0 BIBLIOGRAPHY

1. Final Report, Task Force on Arsenic, Canadian Public Health Association, Yellowknife, Northwest Territories (1977).

2. Hazra, A.K., Prokupuk, R. and Hardus, J.M., "Chemical Characteristics of Snow in the Yellowknife Area, Northwest Territories," Northwest Region, Environmental Protection Services, Environment Canada (1977).

3. Edwards, A.C. and Ken, R.J., "Arsenic Concentrations in Suspended and Settleable Particulate Matter in Yellowknife, Northwest Territories," Northwest Region, Environmental Protection Service, Environment Canada (1979).

4. Atmospheric Environment Service, Environment Canada, Yellowknife Weather Office, "Weather Summary," October 1985 to March 1986.

5. Health and Welfare Canada, "Guidelines for Canadian Drinking Water Quality, 1978."

6. Gray, D.M. and Male, D.M., "Handbook of Snow," Pergamon Press (1981).

7. Johannessen, M. and Henriksen, A., "Chemistry of Snowmelt Water: Changes in Concentration During Melting," Water Resources Research 14, 4, P. 615 (1978).

APPENDIX A:
SAMPLING AND ANALYSIS - REPEATABILITY OF RESULTS

SNOWCORE SAMPLES IN THE YELLOWKNIFE AREA

Table A: SAMPLING AND ANALYSIS - REPEATABILITY OF RESULTS

Site location	arsenic (mg/L)				pH			sulphate (mg/L)			
	top	middle	bottom	average	top	middle	bottom	top	middle	bottom	average
Typical levels of arsenic and other parameters											
24	0.035	0.017	0.019	0.024	7.1	6.5	6.6	1.8	<0.5	0.9	0.9
24	0.035	0.014	0.017	0.022	7.0	6.4	6.5	2.0	<0.5	0.7	0.9
Range of levels of arsenic											
16		0.019									
16		0.024									
24	0.035	0.017	0.019	0.024							
24	0.035	0.014	0.017	0.022							
40	*	*	*	0.095							
40	*	*	*	0.100							
22			0.135								
22			0.130								
41	*	*	*	0.900							
41	*	*	*	0.880							
Range of levels of sulphate											
27										<0.5	
27										<0.5	
33									0.5		
33									<0.5		
20										1.3	
20										1.1	
29								1.7			
29								1.8			
12									4.7		
12									4.2		
16								4.5			
16								4.7			